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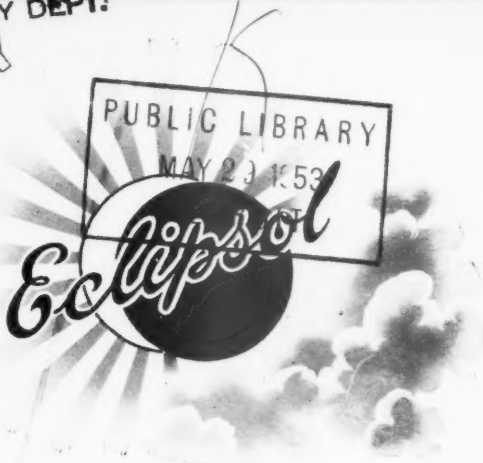

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THE ELEMENTS OF CATHODIC PROTECTION*

By K. A. SPENCER

It is estimated that the cost of replacing corroded buried piping amounts to £5,000,000 annually in the U.K., in spite of the fact that protective coatings of one type or another have been used almost from time immemorial.

Many improvements have been made in protective coating technique during the last two decades, but it is still impossible to obtain permanent protection of buried metal structures by this method alone at an economic cost.

On the other hand, rapid advance has taken place during the last two decades in the application of cathodic protection, which does not normally aim at replacing coatings, but in covering their points of failure, and so provide permanent protection at a very economic cost. Cathodic protection without coatings can be expensive, while coatings without cathodic protection will not remain effective. The cost of cathodic protection supporting a coating is cheap compared to the initial cost of the coating and the two are complementary. It is obvious that there is a balance to be obtained between the money to be spent on coating and cathodic protection to gain optimum value, and this varies according to site and soil conditions.

Causes of Corrosion

At failures in the coating of a buried structure such as a pipeline, the metal finds itself in contact with soils of varying soluble salt, oxygen, and water content, which results in different electrode potentials at these points. Where the electrode potential is highest,

*Resumé of paper read before the South-Eastern Branch of the IP in April 1952.

usually in high soluble salt zones in the soil, metal ions leave the metal surface resulting in pitting corrosion, and this point is regarded as "anodic". Positive electrical current flows from the anodic area through the soil or water to a second failure in the coating, where it re-enters the metal providing protection and this second zone is known as "cathodic". Balance of the electrical system is obtained by the flow of electrons from the anode to the cathode via the metal pipe wall to neutralize hydrogen ions which deposit at the cathode simultaneously as the metal ions leave the pipe at the anode, as illustrated in Fig 1. The corrosion mechanism outlined above is that of "concentration cell" effect and is commonly encountered everywhere, particularly in desert regions.

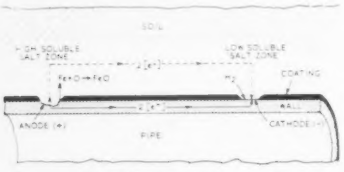

Fig. 1. Simplified corrosion mechanism.

In city and urban areas where electric tramways operate, "stray direct currents" in the ground follow the line of least resistance, which may well be a pipeline. Entering the line at failures in the coating in one zone protection is provided, but where the current leaves again to re-enter the soil and return to, say, the power station source, corrosion of the pipe will occur. To prevent this corrosion suitable insulated wire bonds can be connected between the pipeline and the source, and the stray currents can then supply cathodic protection by what is known as "polarized drainage," which is very popular on the Continent.

If two different metals are electrically connected and immersed in an electrolyte such as soil or water, the one with the higher electrode potential will corrode. For instance a brass valve on a steel pipe accelerates the corrosion of the pipe adjacent to it. This "galvanic corrosion" effect is more often encountered in process plant rather than on buried and submerged structures.

As previously mentioned, hydrogen is released at the cathodic metal surfaces and when it covers a surface it is said to be "polarized". This hydrogen film raises the electrical resistance of the electrolyte circuit and in cutting back current flow reduces corrosion at the anodes. In anaerobic waterlogged conditions the presence of sulphate-reducing bacteria, generally known as "vibrio-desulphuricans" as part of its metabolism absorbs the cathode hydrogen, results in greatly increased corrosion at the anodes. The effect of sulphate-reducing bacteria is widespread in the U.K. Investigation in the U.K. tends to indicate that alkalinity built up adjacent to cathodically protected steel renders the bacteria inert at Ph values of 9 and above. It is also possible that the suppression of corrosion, largely attributable to sulphate-reducing bacteria in both the U.S.A. and the Middle East, may also be due to the supply of hydrogen to the cathode at a rate greater than the bacteria can accept.

The Principle of Cathodic Protection

From the above it will be seen that corrosion is associated with a flow of direct current from the metal to the electrolyte. The simple conception of cathodic protection is to ensure that current is always flowing from the electrolyte to the metal by holding it electro-negative to an external anode of higher electrode potential. In other words the natural anode, which existed on the structure, is replaced by an external expendable anode which may be replaced periodically.

Cathodic protection may be provided by electrically connecting to the structure metals such as magnesium, aluminium, or zinc which, having

higher electrode potentials than iron, become anodes and supply current which flows through the ground to exposed points on the structure. Alternatively scrap cast iron, steel, or carbon can be rendered electro-positive and anodic to the structure by an external source of direct current as shown in Fig. 2.

The Application of Cathodic Protection

A warning should be given that while the conception of cathodic protection outlined above is simple, the successful practical application of cathodic protection calls for considerable experience and "know how".

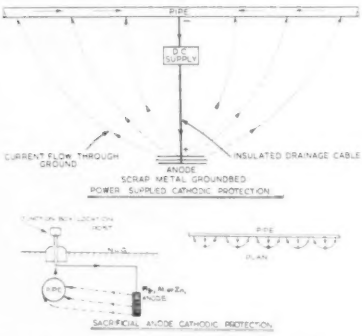

Fig. 2. Application of cathodic protection.

Surveys

It is essential to know the nature of the ground in which the structure exists or is to be constructed. The most useful survey is that for electrical resistivity of the ground. High resistivities indicate low soluble salt content in the ground with low corrosion rate and vice versa. Fig 3 shows anticipated bare pipe life against soil resistivity. This curve is only indicative, but conforms in general to experience as to the period before holing occurs. It cannot be taken as strictly applicable under conditions where sulphate-reducing bacteria are active.

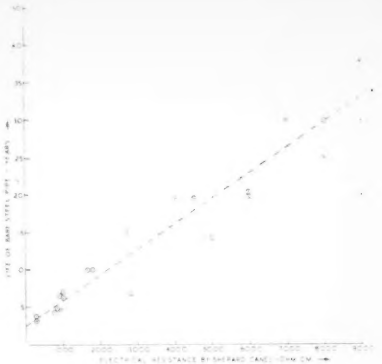

Fig. 3. Bare pipe life v. soil resistivity.[1]

If the structure already exists, power-supplied protection as shown in Fig 2 may be applied in the form of a "drainage test" to assess quality of the coating by recording the current consumed. The greater the current required for protection the greater is the extent of metal exposed.

The data provided by the soil resistance, drainage test, and nature of the structure determine the type and engineering design of the protection to be used.

Criterion for Protection

It is necessary to know when sufficient current is flowing into the structure from the soil to give polarization at all exposed metal. For this purpose a copper/copper sulphate half-cell is placed, preferably within six inches, of the structure in contact with the soil and connected to the positive terminal of a potentiometer, valve voltmeter, or high internal resistance (100,000 ohm/v) voltmeter. The negative terminal is connected to the structure via a metal circuit as shown in Fig. 4. Natural pipe/soil potentials usually range from 0.35 to 0.7 and it is generally accepted that if current sufficient—0.85 v—to make this potential is flowing into the structure protection will be provided.

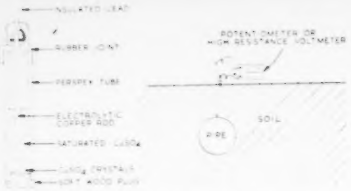

Fig. 4. Measuring pipe soil potential.

According to soil conditions the amount of current required may normally be between 1 and 15 mA per square foot of exposed metal.

Equipment

(i) *Sacrificial Anodes.*—Anodes such as magnesium, aluminium, or zinc which, as previously explained, provide protective current for the structure in corroding or "sacrificing" themselves, find especial application where piping may be complicated, as in a refinery site or where power supply is not available. Their low available forcing potential as shown in Table I limits their use to water or soils up to 3000 ohm/cm resistance, but they are very useful in this corrosive range.

TABLE NO. 1

Anode Electrode Potentials (V 0·1 N Calomel Cell)

	V	*Amp-hours per lb*
Magnesium . . .	1·90	997
Aluminium . .	1·23	1352
Zinc	0·32	372

Magnesium modified with 6 per cent aluminium and 3 per cent zinc, and limitation of other properties, is the most popular anode material because of its high electrode potential and low tendency to anodic polarization.

The ampere hours per lb quoted are for 100 per cent electrode efficiency, but local action on the surface of the anode usually reduces this to 20 to 50 per cent giving 200 to 500 amp hours per lb for magnesium.

Frequently the anodes are backfilled with bentonite and gypsum mixtures to increase electrode efficiency by lowering resistance and retaining moisture.

The anodes themselves are supplied in cylindrical form of various weights, 22 and 50lb being popular. A 200- or 250-lb hemispherical anode for protection of jetties is so designed to sit firmly on the sea bed.

The number of anodes spaced along a structure and connected to it depends on the quality of the coating on the structure, its size, the soil resistance, and many other factors which cannot be taken into the scope of this short resume.

Power Supplied Systems.—Cathodic protection by direct current supplied by scrap metal or carbon anode groundbeds as shown in Fig 2 is favoured where ground resistances in general are above about 3000 ohm/cm or where large exposed areas of metal are involved. One groundbed will frequently provide protection for some 40 miles of pipeline.

The current may be drawn from direct current supplies, transformer-rectifiers with the more commonly encountered alternating current, converters, engine or windmill driven generators, storage batteries, and recently from thermo-pile units.

The groundbeds corrode per ampere flowing at the rate of 15 to 20 lb/annum for steel, 2-20 lb/annum for cast iron, and approximately 2 lb/annum for carbon. At the groundbeds heat is generated and water consumed, so to maintain the resistance of the groundbed to soil as low as possible they are located in wet, salty ground and devices such as water drainage to the groundbed used as shown in Fig. 5. Groundbeds may be as much as a mile away from the structure they are protecting, but design of such systems is complicated, depending largely on tests and experience for each installation.

The power supplied form of protection, which can be easily adjusted, is finding increasing popularity.

Economics of Cathodic Protection

The conclusion being reached that coating alone will not provide permanent protection against corrosion, the inevitable question is how much will the extra cathodic protection cost? There is obviously an optimum balance between the quality and cost of the coating and the cost of the cathodic protection. It is difficult to generalize except to say that the cost of the cathodic protection is usually a fraction of that of the coating, and it is proposed to quote two authorities on this subject of economics.

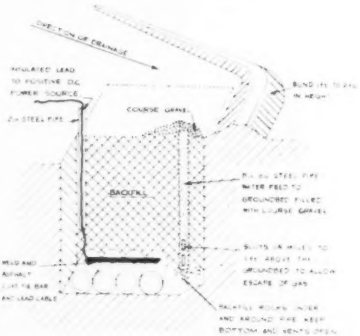
DIRECTION OF CHANGE
INSULATED LEAD TO POSITIVE D.C. POWER SOURCE
COURSE GRAVEL
2" STEEL PIPE
BACKFILL
MUD AND ASPHALT COATING BAR AND LEAD CABLE

Fig. 5. Ground bed installation.

Good[2] states that 70 miles of 10-inch coated pipe started leaking after three years and after $6\frac{3}{4}$ years leaks had cost $47,000. Cathodic protection was then applied and after 15 months no further leaks had occurred. Fig 6 shows graphically the accumulative cost of the leaks and the cost of the cathodic protection against age of the pipe.

Peabody and Woody[3] describe the experiences of two companies in the U.S.A., which supply natural gas to 236 cities through 5200 miles of 3-inch equivalent mains. Because of reduced

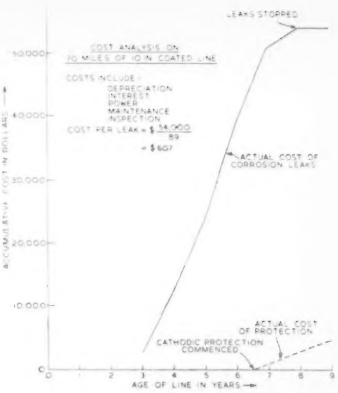

Fig. 6. Cathodic protection economics.

corrosion due to application of cathodic protection, one concern is now buying thinner walled pipe and the saving of steel is 7 to 40 per cent, depending on pipe size, the average being 20 per cent. One of the systems is being protected by anodes for 40 years life at less than $5 per mile per annum, which is less than the installation cost of the smallest leak clamp.

The author's own experience with the recently constructed 12-inch oil pipeline across Scotland indicates that the cost of the cathodic protection is of the order of £3 per mile per annum, which is very economic as an insurance measure.

Conclusion

Many highly successful cathodic protection installations now exist to prevent corrosion of pipelines, tank bottoms, jetties, sheet piling, bridge structures, tubular heat exchanger equipment, telephone and power cables, etc.

Each structure raises its own problems and it must be emphasized that survey, engineering design, and balancing of the system should only be undertaken by experienced personnel if satisfactory results are to be obtained,

and advantage obtained from this relatively new means of preventing corrosion.

The author wishes to express his thanks to the chairman and directors of the Anglo-Iranian Oil Co. Ltd., for their permission to publish this résumé.

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3. Peabody, A. W., and Woody, C. L. *Corrosion* 1949, 369-377.

The author informs us that, since this paper was originally delivered, considerable developments have taken place, in particular with regard to cathodic protection in soils containing sulphate-reducing bacteria and in the extended use of graphite as anode ground bed material.

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PETROL STORAGE IN JERRICANS

In connexion with the mention of the illegality of the storage (without prior notification) of jerricans of petrol (p. 53 of the February issue) Mr Stevenson, Chief Petroleum Officer, City of Plymouth, writes to say that the increasing difficulty of obtaining the pre-war type of standard 2 gallon petrol can is making storage within the law a matter of increasing difficulty for local authorities, contractors, road repairers, etc., not to mention the private motorist.

This suggests to him that the time may well have come when the existing regulations should be revised making storage (without prior notification) permissible in larger cans.

Correspondence which he had on this subject with the Explosives Department of the Home Office about a year ago indicated that the question of permitting such storage in jerricans was under consideration. It would be interesting to hear from the authorities concerned whether they have reached any conclusions on the advisability, or otherwise, of amending the storage regulations in this respect.

PETROLEUM IN PARLIAMENT

Dollar Oil Imports

In a written answer on 10 March the Minister of Fuel and Power said that the f.o.b. value of petroleum imports into the U.K. paid for in U.S. or Canadian dollars was £46 million in 1950, £87 million in 1951, and £54 million in 1952.

Tanker Construction

The First Lord of the Admiralty said, in a written answer on 16 March, that 97 tankers were under construction in the U.K., 61 for owners in the U.K., 21 for Norway, 6 for Greece, 3 for the U.S., 1 for Italy, and 5 for Panama. The shortage of steel was affecting the rate of construction but there was no case of serious interruption of work.

Oil in Lahej

The Colonial Secretary said he was not aware that any oil deposits had been found near Lahej, north-west of Aden, in a written reply on 18 March.

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EQUATOR-ARCTIC EXPEDITION

The Austin A.40 Somerset car which, as reported in our last issue, left the Equator on 17 March reached its destination at Jokkmokk, inside the Arctic Circle on 28 March. Due to the breakdown of the guide car insisted upon by the Sudan authorities, three days and nights were lost but, by flying from Cairo to Marseilles and much high-speed driving across Europe, the journey of 7,000 miles of hard driving under extremes of climatic conditions was completed in the scheduled time of 12 days.

On arrival at London Airport on 2 April, the three drivers, Alan Hess, Ken Wharton, and Ron Jeavons, paid a tribute to the car—an ordinary British family saloon—and to their fuel and lubricants provided by the Vacuum Oil Co. Ltd.

At the Persian Gulf Branch luncheon. (L. to R.) E. A. Skinner, Sir Charles Belgrave, E. Boaden, H. S. Gibson, R. Godfrey, Sir Rupert Hay, G. Heseldin, R. M. Brown.

AROUND THE BRANCHES

FAWLEY, LONDON, NORTHERN, PERSIAN GULF, SCOTTISH, SOUTH EASTERN, SOUTH WALES, STANLOW, TRINIDAD

Persian Gulf Branch

On 12 and 13 February 1953, the Persian Gulf Branch of the Institute held its first annual meeting in Bahrain. The two-day meeting opened with a luncheon at "Al Dar", The Bahrain Petroleum Company's guest house in Awali, given by the Bahrain Sub-Area in honour of the President, H. S. Gibson, C.B.E. Other distinguished guests included His Excellency Sir Rupert Hay, K.C.M.G., K.C.I.E., C.S.I., Her Britannic Majesty's Political Resident in the Persian Gulf; Sir Charles Belgrave, K.B.E., Adviser to His Highness the Ruler of Bahrain; E. A. Skinner, Vice-President, Bahrain Petroleum Company Ltd.; E. Boaden, O.B.E., Assistant General Manager, Kuwait Oil Company and Chairman of the Persian Gulf Branch; Dr A. J. S. Perfect; G. Heseldin, General Manager, Petroleum Development (Qatar) Ltd., and several members from Qatar and Kuwait.

In welcoming the guests, the Bahrain Sub-Area Chairman, R. Godfrey, said that he did so with feelings of pride and responsibility—pride, that in the short time the Branch had been in existence, they had attained the prestige indicated by their presence, and responsibility, in having attained that stature, in their obligation to the Institute and to the oil industry as a whole. Mr Boaden introduced the President who, in a very interesting talk, stressed the importance of a Branch of the Institute of Petroleum in an area which, he said, contained about half of the known oil reserves of the world but produced as yet only 16 per cent of the world's consumption. Mr Gibson then traced the fascinating history of oil developments in the Middle East, paying tribute to the efforts and vision of the pioneers who had great difficulties to overcome in the early days. A vote of thanks to the President was proposed by G. A. Hogg, Secretary of the Persian Gulf Branch, and carried with acclamation.

Replying to an expression of thanks for the generous assistance received from Bapco in making the meeting a success, R. M. Brown, Vice-President

and General Manager, The Bahrain Petroleum Co. Ltd., expressed regret that the past President, C. A. P. Southwell, C.B.E., who was visiting Kuwait, had not been able to be present.

Later, on Thursday afternoon, 12 February, a paper entitled "Some Corrosion Problems encountered in the Mina-al-Ahmadi Refinery" by V. J. Chir, K. Turner, and F. H. Colenutt, was read by Mr Chir. The discussion which ensued was very ably handled by Messrs Chir and Turner—Mr Colenutt was, unfortunately, unable to be present.

A tour of places of local interest was arranged for Friday morning and this included visits to various Bapco installations of interest to the visitors from Kuwait. The tour was followed by a paper, "The Operation of a Products Pipeline by Batching Through an Enclosed System" by A. L. Smithers, which, in his absence, was presented by M. J. L. Rogers. Though somewhat handicapped in presenting a paper which had been prepared by someone else, Mr Rogers handled the very interesting discussion which followed in a capable manner.

Bahrain Sub-Area

The Annual General Meeting of the Bahrain Sub-Area was held on 13 February and R. Godfrey was unanimously re-elected as chairman, and W. D. Clarke, R. Godfrey, L. E. Machin, and M. H. Whitehead were elected to the Sub-Area Committee for the coming year. W. D. Clarke was elected Hon. Secretary and Treasurer in succession to K. S. Lennie. This was followed by the Annual General Meeting of the Persian Gulf Branch at which the Chairman, Mr Boaden, presided. Later in the evening a colour film, "The Bahrain Story" was shown. In introducing the film, Mr Godfrey related the events leading to the discovery of oil on Bahrain, which, he said, was one of the most important landmarks in the history of Middle East oil. Not only was Bahrain the discovery field on the western shores of the Persian Gulf, but it was the result of testing deeper formations in Bahrain which encouraged the Arabian-American Oil Company, then operating as The California Arabian Standard Oil Co., after several unsuccessful wells, to drill deeper and develop the very prolific horizons now known as the Arab Zones.

A general view of the assembly at the Persian Gulf Branch luncheon.

At the close of the meeting, Mr Godfrey thanked the retiring Honorary Secretary, K. S. Lennie, for his work for the Sub-Area, which members applauded, and also thanked all concerned in the arrangements for the Annual Meeting, including Huntly Spence, who, until recently, was Vice-Chairman of the London Branch.

All the visitors expressed their appreciation of, what was for all the members, a most enjoyable and interesting gathering.

The 11th Ordinary General Meeting of the Bahrain Sub-Area was held on 15 March 1953. The main part of the meeting was the showing of a film "The Fawley Achievement", loaned by the Esso Petroleum Company Ltd. The film depicts the construction of the Esso Petroleum Company's refinery at Fawley from the ground breaking in the autumn of 1949 until the opening ceremony in September 1951. The film proved very popular with 30 members and applicants for membership and 24 guests in attendance.

After the film, L. E. Machin led a discussion on the film. Mr Machin started the discussion by comparing the Fawley construction with the Bahrain Petroleum Company's aviation construction project at Bahrain during 1943-45. He drew many comparisons and pointed out several differences in the two construction projects. An interesting discussion followed in which several members and guests took part.

South-Eastern Branch

It would appear that the Clerk of the Weather has frowned on the activities of the South-Eastern Branch of the Institute of Petroleum during the present Session in so much that the February meeting had to be cancelled due to the national disaster of extensive flooding around the East coast of Britain, and that fog descended on the Medway area on the evening of 3 March, which was the night of the Branch meeting. However, in spite of adverse weather conditions 35 members were present, which was a tribute to the enthusiasm of the Branch.

On this occasion H. C. Carter of Messrs Le Grande, Sutcliffe & Gell presented a paper on the drilling and producing of oil. His talk was accompanied by a film strip and diagrams. During his talk Mr Carter covered the field of drilling from the ancient spring board method devised by the Chinese, which led to the modern method of percussion drilling, to the modern methods of rotary drilling by means of which wells have been drilled to a depth of over 20,000 ft.

The subject chosen by Mr Carter for his talk is so complex that he could only hope to deal briefly with its many aspects. However, members were given a very good insight into this subject, this being apparent by the interesting questions discussed at the end of the talk.

Fawley Branch

The February 1953 meeting of the Fawley Branch of the Institute was held at Holbury on 20 February 1953, with an excellent attendance of members.

Dr F. Mayo, refinery manager, took the Chair and introduced the speaker, J. Melville of Vickers-Armstrongs Ltd.

Introducing his subject of "The Construction of a Modern Large Oil Tanker", the lecturer reviewed the historical side of the carriage of oil in bulk, giving particulars of the efforts of shipbuilders and shipowners to provide as safe a passage as possible for oil, from 1872 to the present day. Special reference was made to the vessels built at the Barrow works of Messrs Vickers-Armstrongs Limited, mention being made of the *Hainaut*, a three-masted sailing vessel built in 1887, which carried 2500 tons of petroleum, and which is the oldest oil tanker still afloat. The first steam-driven tanker built at Barrow was the *Northern Light*, completed in

1893, with a deadweight of 5400 tons, but by 1922 the usual large tanker was of 10,000 tons deadweight. Today vessels of over 31,000 tons are sailing the seas, while others of 45,000 tons are under construction.

The main portion of the talk dealt with the design and construction of a typical 31,000-ton tanker, 625 feet in length, breadth 86 feet, depth 45 feet 6 inches, speed 17 knots, with a crew of 50. Passing briefly over the preparation of the underwater form and the tests made in the experimental tank, the lecturer proceeded to detail the various processes passed through in the drawing office, mould loft, fabrication and assembly shops, and on to the building berth. The up-to-date facilities provided at Barrow enable the structure to be prepared on the ground in large units, up to 50 tons in weight, and these are transported to the berth for erection. The special care and accuracy in fabricating and fitting these units in proper sequence to ensure minimum distortion and the elimination of locked-up stresses as far as practicable was demonstrated, a series of slides being shown to illustrate the methods used.

The arrangements made for the successful launching of the vessel, weighing over 8000 tons, from the berth to the water were explained and the talk concluded with a brief description of the propelling machinery and some of the multitudinous items, pumps, piping, outfit, furnishings, etc., that go to make up the completed tanker, which today forms so essential a part of the Nation's economy.

Following his lecture Mr Melville gave replies to questions which were put to him by his very interested audience.

The meeting closed with a vote of thanks to Mr Melville, proposed by Dr A. W. Pearce.

Stanlow Branch

At the Stanlow Branch meeting on 18 March, E. A. Evans, past-president and Branches lecturer gave his address on "Lubrication—Chemist or Engineer?"

The speaker explained the object and origin of the Branches lecture and commented on the trends of professional training for chemists and engineers, with particular reference to the lubricating side of the petroleum industry.

The development of prime movers and, with them, of the need for adequate lubrication was outlined. The problems posed by the increasing temperature and pressure of modern engines were described and the way in which such problems had been met by the development of additives was indicated.

The discussion on the lecture was opened by Dr J. B. Matthews and continued by several other speakers from the audience.

The vote of thanks to the speaker was proposed from the Chair.

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U.K. OIL SEARCH

D'Arcy Exploration Co. (AIOC subsidiary) is undertaking oil exploration at Radcliffe-on-Trent, where the National Coal Board recently discovered small quantities of oil.

The company's four producing fields —Eakring, Duke's Wood, Kelham Hills, Caunton—last year produced some 55,000 tons of crude.

Compressed Air Dangers.—In these days when compressed air equipment is found in everyday employment, the dangers of its indiscriminate use cannot be too widely known. With the object of directing attention to the dangers of misuse, a small 8-page pamphlet *Compressed Air can be Dangerous* has been made available by the Royal Society for the Prevention of Accidents, 52 Grosvenor Gardens, London, S.W.1, at prices from 10s for 50 copies to 150s for 1000 copies.

SOME CORROSION PROBLEMS ENCOUNTERED IN MINA-AL-AHMADI REFINERY*

By V. J. CHIR (Associate Fellow), F. H. COLENUTT, M.B.E. (Associate Fellow), and K. TURNER

Corrosion problems encountered in Kuwait refinery may be divided roughly into two categories, those pertaining to the actual processing of crude and those arising out of the use of sea water as cooling medium.

Brief Description of Unit

The primary purpose of the existing refinery is to supply as far as possible fuel for tankers loading crude oil at the Mina terminal.

Local requirements of motor spirit, gas oil, and kerosine are fully met, but constitute some 3.5 per cent only of total refinery throughput.

The plant is a single-stage atmospheric crude oil distillation unit of 25,000 b.s.d. capacity. The design incorporates the use of stripping steam at the column base with side cuts of gas oil and kerosine which are steam stripped in separate vessels. An overhead distillate of approximately 170°C E.P. is normally produced and part refractionated and stabilized to produce a medium motor gasoline which, after treating and leading to 70 O.N., supplies the local market. A light residue of viscosity about 1400 sec Redwood I at 100°F and constituting some 60 per cent by weight of total feed, is drawn off as a bottom product and blended with gas oil and surplus kerosine to produce the required grades of marine fuel.

The tube-still is of conventional twin pass design, gas fired at one end and employing carbon steel tubes.

Kuwait crude is very low in H_2S content and with a transfer temperature maintained at 560°F the formation of additional H_2S in the heater is negligible. Nevertheless, in accordance with current practice for the protection of mild steel plant against H_2S corrosion, a system for the introduction of caustic soda into the crude feed is in operation, and it is in the functioning of this equipment that corrosion-erosion problems were first experienced.

Crude Processing

Soda System

The method of caustic injection as originally used was to introduce hot residue at about 470°F into a small existing flash tower along with 15 per cent aqueous caustic soda. The vessel is of cast iron and packed in the centre section with cast iron raschig rings. The soda was injected through a jet nozzle into the middle of the packed section where its water content was supposed to flash off, the vapour finding its way via a balance line into the main topping tower, while the turbulence created in the flash tower would cause an "emulsification" of the oil with completely de-hydrated soda.

This "emulsion" was drawn from the base of the flash tower and delivered by means of a high speed two-stage centrifugal pump into the crude charge line between heat exchangers and heater, discharge pressure required being in excess of 300 p.s.i.g.

Among the first troubles to be encountered in this equipment was the repeated failure of the 3-inch suction line from the base of the tower, pin-hole leaks occurring at bends in the pipe after periods of three weeks operation only. At the same time trouble arose in the emulsion pumps due to seizing of wearing rings, and inspection showed

*Read before Persian Gulf Branch of IP in May 1952.

that these rings had cracked at points around locating screws. As the stock of specified parts had already been exhausted, bronze rings were fitted as a temporary measure and performed satisfactorily. Cracking of the pump bodies below the flanges of discharge occurred later and inspection revealed that covers and impellers were full of intercrystalline cracks. Attempts were made to weld the worst of these but without success, as due to expansion caused by the heat of welding, further cracks appeared on the unwelded portion. New pump bodies, impellers, and covers were ordered and the system remained out of commission until these arrived.

It was found that failure of the suction line was due to abrasive action of small pellets of caustic soda caused presumably by incomplete atomization and dehydration of the aqueous caustic.

The reasons for this unsatisfactory operation were not at first apparent and temporary measures adopted to combat this problem consisted of the installation of a suction line made up of small sections for easy renewal, of relaying it with a view to eliminating bends as far as possible, and experiments with soda injection nozzles of modified design. Adjustments to the flow of hot residue into the system were also carried out, this flow being in the region of 12 gal/min, a figure later established as optimum for the size of plant and the quantity of caustic soda injection.

The condition of the pumps had undoubtedly been brought about by caustic embrittlement, so the question of pump specification was then reviewed. The pump originally installed was the two-stage centrifugal type revolving at 3600 r.p.m., driven by 30-h.p. motor through a step-up gear box of 2:5 ratio, the main construction of the body, impellers, covers, and wearing parts being of specially stabilized and annealed type 347 stainless steel. Some consideration was given to substitution with multistage pumps operating at a much slower speed, but as the result of enquiries it was decided to retain the high-speed two-stage pump, but to order replacements for body, end covers, and impellers of Meehanite (Moly C.1), wearing rings and spacer sleeves of Monel, and shaft sleeves of 11/13 per cent chrome nickel Stellited over.

The various troubles experienced on this equipment caused frequent and some time-prolonged shut downs of the soda flash system; in fact, it is probable that it was not in operation for more than 70 per cent of the total unit stream hours at that time.

The modifications carried out on the emulsion suction line and the injection nozzle did effect considerable improvement in the continuity of operation, but as caustic embrittlement of the emulsion pump and pelletization of the caustic soda continued, attention was concentrated on the functioning of the flash tower itself.

It was eventually established that the flow of vapours through the overhead balance line was insufficient to prevent condensation of water vapour in the balance line and possibly, to some extent, in the column top itself, with the result that condensate periodically found its way back into the flash section causing violent surging and presumably preventing the complete dehydration of the soda solution.

It was obvious that the release of hot vapours in the tower would have to be increased to overcome the tendency for the tower top and balance line to cool off. This was achieved by the introduction of a small quantity of preheated crude into the system with the hot residue. The quantity of crude injected was governed by the need to keep the temperature well up in the vessel, preferably not less than 450 F, as an excessive amount of crude would tend to drop the temperature of the flashing operation.

No further trouble was experienced in operation after this change had been effected and pumps had been rebuilt with new parts. Further inspection of the latter showed only normal wear, but it is of interest to note that the new impeller diameters were increased from 9-13/16 to 10 inches and are giving a constant discharge head of 350 p.s.i.g.

It, therefore, remained only to establish the correct amount of caustic soda for optimum protection of the main plant.

During the many periods when the soda system was out of commission, it was observed that the iron content of the run down accumulator water was up to 500 ppm., a figure which represented the loss of some 26 lb of iron per day, while its pH value was in the region of 3.2 only. On resumption of alkali treatment, the pH value rose to 5.3, this figure being achieved by the use of some 180 lb of caustic soda per million gallons of crude, while the iron content was reduced to 20 ppm. Further increases, however, in the amount of soda injected had no further effect on the pH value.

Overhead Condenser System

After completing six months operation from initial commissioning the main unit was shut down for inspection and overhaul. Overhead equipment, such as vapour line, condensers, and run down line gave no indication of any severe corrosion. The laboratory tests on the accumulator water during alkali treatment seemed, therefore, to indicate adequate protection at the time and no serious concern was felt until the annual overhaul of the main plant in November 1951, 12 months after commissioning, when conditions were found to be very much altered.

Condensing equipment in the refinery consists of two pairs of conventional horizontal closed condensers arranged to form first and second stages in two separate banks, and on this shut down it was found that first stage condenser shells had been reduced in thickness from $\frac{1}{2}$ to 9/64 inch in places. The second stage shells had corroded to a much lesser degree.

This severe corrosion was mainly in the area at the temperature corresponding to the dew point of the vapours being condensed and had also attacked the tube bundle baffle plates and stay rods. There was also wastage in the run down line immediately under the condensers.

To overcome the immediate problem of the wasted shells, a doubling plate $\frac{3}{4}$ inch thick was welded around the bottom half over the full length, and to relieve any pressure which might develop behind these plates, pet cocks were installed and left open during operation. This served satisfactorily until new shells were obtained and fitted.

Most of this corrosion was obviously a direct result of the failure of the emulsion system, which had allowed maximum formation of corrosive HCl by hydrolysis of magnesium chloride present in the crude. As the maximum pH value of run down water obtained with the use of caustic soda alone was still considerably below the neutral value of 7.0, some further improvement was, therefore, desirable in the efficiency of the treatment.

It is probable that the use of caustic soda suppresses to some extent the occurrence of corrosive HCl in distillation column overhead vapours but, in order to take care of any free HCl still being formed, further treatment of the overhead vapours themselves is required. It was, therefore, decided to introduce the well established use of free ammonia gas, as follows:

Ammonium sulphate is added to the caustic soda solution and when injected into the soda flash tower, free ammonia flashes off and is carried into the main column via the balance line which enters at the vaporizing section. Ten lb of

ammonium sulphate per m.g.c.f. gives two lb free ammonia per m.g.c.f., and this has proved quite sufficient to maintain the pH value of the accumulator water at the required figure, the iron content then being reduced to nil.

Corrosion from Sea Water

Running parallel to and affecting to some extent equipment already under discussion was an increasing problem of corrosion in pipe work, condensers, coolers, and pumps, caused by the use of sea water cooling. Corrosion was affecting both ferrous and non-ferrous metals and to give a clear picture of the problem, a brief outline of the sea water supply system is given.

Water is taken from a small boat harbour at Mina-al-Ahmadi, rotating screens preventing unwanted matter from entering the pump suction. The water is delivered to a 50,000-barrel steel tank from which suction is taken by the refinery booster pumps.

The first corrosion by sea water was noticed in the steel lines to the booster pumps and later in those to the condensers and coolers. Considerable concern was felt at the time over the steel underground piping within the battery limits of the plant. This ran under the concrete paving slabs and, had a leak occurred, it might have had serious effects on the unit foundations before being detected.

It was, therefore, decided to revamp all the cooling water lines below ground level, and run them in the overhead pipe tracks. This left the piping under observation and also cut out the possibility of external corrosion from soil.

Similar problems arose in the corrosion of channel and floating heads of condensers and pitting of condenser tubes in coolers.

The condensers are constructed of steel channel and floating heads, naval bronze tube plates and, initially, tinned, inhibited Admiralty mixture brass tubes.

Channel and Floating Heads

Considerable wastage was found on channel heads and floating head covers of condensers and coolers after only six months operation, the most severe corrosion being noted around the gasket faces between condenser tube plates and end covers. This was obviously due to electrolytic action caused by the lower potential of the steel as compared with that of the non-ferrous tube plates under operating conditions.

Marine growth consisting mainly of live barnacles was also well established at this time in the channel boxes, and chlorine shock treatment of the incoming sea water was put into operation shortly afterwards at the sea water pumphouse.

The only anti-corrosion measure actually then taken was the installation of sacrificial zinc blocks inside the floating head covers, though it was felt that as the space available was too small to accommodate anodes of useful size, little would be gained by this.

A decision was taken, however, to install magnesium blocks in the channel boxes at the first opportunity, magnesium, with its high e.m.f. of -1.55 volts in sea water media, being recognized, and also because of its high electrochemical equivalent in ampere-hours available per pound of metal and its ability to maintain high current output throughout its life as an anode.

At the following plant shut down, i.e., 12 months after commissioning, further heavy corrosion was evident on this equipment, and division plates were renewed on condenser channels, cooler floating heads were built up with 18/8 stainless steel by electric welding, and four new covers were fitted to condenser floating heads.

Magnesium blocks were fitted experimentally in some channel boxes as there was some doubt at the time as to what extent they might interfere with the free flow of coolant. As space was the limiting factor in the installation of anodes in the floating heads, it was

also decided to order all these replacement heads in non-ferrous metal.

The practice of painting heads and covers with red lead was abandoned, except where cathodic protection was used, as it was believed that holidays occurring in this covering would tend to create anodic areas which would concentrate corrosion at these points.

A further six months' operation proved the efficiency of the magnesium blocks, but the quantity of magnesium installed had been insufficient to last the full period between shut downs, so larger blocks were fitted in each head. The problem of protecting the floating heads remained, and at this time a suggested method of protecting them was incorporated. This consisted of passing an insulated wire from a magnesium anode mounted in the channel head and itself insulated from its mounting, through the condenser tubes to a centre point on the floating head cover.

This latter device subsequently proved ineffective, but further inspection did prove that excellent protection was now being given to the steel channel heads by the use of the large magnesium anodes. One difficulty arose in that the large quantity of protective magnesium and calcium carbonate scale formed tended to break away periodically in thick lumps which were held against the tube sheets and caused partial blockage of tubes.

In order to reduce the rate of wastage of the magnesium blocks and thus reduce the formation of the heavy scale, their current output was measured by means of a wire leading from the insulated magnesium block and brought through an insulated gland screw in the channel head cover to complete the circuit externally, so that a voltage reading could be taken. The current output thus established, it was possible to install suitable resistances in the anode circuits, and by this means control the current density and rate of loss of the anode.

Tube Failures

The tubes originally installed were of the following composition:

Copper	71	per cent
Tin	1.1	per cent
Arsenic	0.04	per cent
Zinc	remainder	

This represents a normal inhibited Admiralty brass tube with perhaps the exception that these were tinned. Although tinning of condenser tubes is not uncommon, the fact had some bearing on the corrosion.

The first tube failure was experienced after 16 months operation, when it was found that severe pitting, with a brownish scab covering, had taken place, particularly on the inlet passes of the condensers and coolers. This came as a shock, as on two previous occasions during overhauls, tubes had been withdrawn for inspection and had been found in good condition, but it should be stressed that up to that time no tube cleaning had been carried out.

This corrosion was later established as being due to "oxide pitting" attendant upon anodic attack caused by the failure of the tinning of the condenser tube surface and the subsequent breakdown, in the presence of sea water electrolyte, of the copper base alloy underlying the tin.

The damaged tin coating was caused either by (*a*) the tin coating being imperfect in the first place or becoming damaged during installation; (*b*) scratching or perforation of the coating during cleaning operations.

This type of corrosion was further aggravated by the rather slow water velocities of about 3.5 ft/sec as against a recommended optimum of 5 to 7 ft/sec. Such conditions probably allowed solid matter in suspension in the cooling water to adhere to the tube wall and form a node, from which anodic attack could start.

All possible steps were taken to improve water velocities but much trouble had been experienced due to blockage of tubes by shell fish, which

had either found their way through the main screens or developed in the lines and tankage of the water system in spite of chlorination. Large strainers were, therefore, fitted with three sizes of mesh screens to the suctions of the refinery water booster pumps. These strainers have eliminated the blocking of condenser tubes and fairly good flows have been maintained over a long period.

The question of replacement tubes has been considered and as a long term policy, cupro-nickel (70-30) tubes have been ordered. This may appear superfluous, but the supply position rather influenced this decision, coupled with the fact that the main steam power house and other refineries operating in the Persian Gulf area were using this type of tube and had sufficient data to confirm their suitability. It is probable that the less costly aluminium/brass tube would, in the existence of low water velocities, have served as well but, as mentioned earlier, the supply position of the cupro-nickel tube was easier at that time.

Further experiments have been carried out on the plant with a view to improving water velocity, such as increasing the size of the effluent line, redesigning the gas oil and kerosine cooling system to operate in series instead of in parallel, and by taking suction with the booster pumps direct from the sea water pumphouse delivery line, thus bypassing the balance tank.

It is doubtful, however, if the desired optimum water velocity can be achieved by these means, but it is hoped that the known higher corrosion resistance of cupro-nickel tubes will facilitate trouble-free operation for an economical period under the conditions obtaining.

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Photography in the Oil Industry.—Recently at their Gallery in Regent Street, London, Kodak Ltd. presented an exhibition of photographs drawn from the 20,000-picture library of the "Shell" Photographic Unit. All phases of the industry were illustrated and the exhibits varied from the picturesque to the strictly utilitarian type of picture demanded in research.

The Case for a Revised Road Policy.—The Standing Joint Committee of the RAC, AA, and RSAC has recently issued a 24-page booklet under the above title. Considerable detail is given concerning motor vehicles, motor and fuel taxation, expenditure on roads, etc., and copies are obtainable from the Committee at 66 Whitcomb Street, London, W.C.2.

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The "British Sailor" leaving the Clyde. This 32,000-ton tanker is the largest to be built for the British Tanker Co. Ltd.

PERSONAL NOTES

H. W. Smith, M.Inst.Pet., has been appointed South East Regional Manager of Fina Petroleum Products Ltd. He commenced his career in the Shipping Department of Esso Petroleum Co. Ltd. (then the Anglo-American Oil Co. Ltd.) in 1921 and joined the Universe Petroleum Co. Ltd. in 1929 and subsequently became a Director. During the war he served with the Petroleum Board and the Admiralty. On demerge of the Petroleum Board he took up his duties as Director of Universe Petroleum Co. Ltd., and was elected as Independents' Representative of the Black Oils Sub-Committee of U.K. P.I.A.C.

Captain **J. C. Lea,** O.B.E., Commodore of the British Tanker Co., is to command *British Sailor*, the first of the Company's 32,000 dw ton tankers.

Herbert J. Dykes, F.I.A.C., M.Inst. Pet., who recently resigned his position of accountant after over 33 years with British Controlled Oilfields Ltd., has been appointed a director of Messrs. D. Y. Grimstone Ltd.

L. J. Windridge has been appointed secretary to Messrs. W. B. Dick & Co. Ltd., in succession to **G. Bowyer** whose resignation is announced, and will continue to act as assistant secretary to Messrs. C. C. Wakefield & Co. Ltd.

J. E. H. Davies has been appointed to the Board of Société Générale des Huiles de Petrole BP, French associate of Anglo-Iranian. He has been Assistant General Marketing Manager (Western Markets) to AIOC since December 1951.

Eugene Holman, president of Standard Oil Co. (New Jersey), has been awarded the Charles F. Rand Memorial Medal by the American Institute of Mining and Metallurgical Engineers.

J. Chapman Davis has been appointed sales manager of Vacuum Oil Company's Marine Branch, in succession to H. S. Yelland.

R. A. J. Fowler, of Esso Petroleum Co's headquarters management, recently received the Alexander Duckham Memorial Trophy of the Institution of the Motor Industry. This was awarded for an essay on "How far do you consider industry should be responsible for the education and training of its personnel."

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BURMA OIL INDUSTRY

Speaking at the Annual General Meeting of the Burmah Oil Company (Burma Trading) Ltd. in Rangoon recently, R. S. Carey, O.B.E., general manager, stated that of all the companies formed to operate in the Burma oil industry, only 20 per cent remained today, the remainder having failed to find oil in commercial quantities.

1952 *Developments*

It was stated that total production of crude oil in 1952 was 645,088 barrels from the Chauk and Lanywa fields. This represented an increase of 0.23 per cent over 1951.

In the Chauk field six new wells were drilled in 1952 and two wells were deepened.

It is hoped that the new refinery at Chauk will be in operation before the end of 1953 and it will then provide about 60 per cent of Burma's requirements of petroleum products, including paraffin wax which has been wholly imported since the war.

BOILER CORROSION REPORTS

The Boiler Availability Committee, which was formed in the early days of the war with the object of reducing corrosion effects in water-tube boilers, has recently issued four further publications:

Second Interim Report on External Deposits and Corrosion in Boiler Plant, 1946-51. (Bull No. MC/234.)

Summaries of Published Papers. (Bull No. MC/235.)

Bibliography of Papers Relating to the External Fouling and Corrosion of Boiler Plant, 1940-51. (Bull No. MC/236.)

Burton Investigation Group Report on the Relation between Chlorine Content of Coal Burned and Availability of a Stoker Fired Boiler. (Tech. Paper No. 3.)

The Committee's work is sponsored by the Water Tube Boilermakers' Association and the B.E.A., and chief engineers may obtain copies of the reports from the manufacturers of the boilers being operated.

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Esso New Midland H.Q.—Esso Petroleum Co. Ltd. has recently acquired the mansion and 111 acre estate of Little Aston Hall, Streetly, near Birmingham. This will become the H.Q. of the Company's Midland Division, at present accommodated at four addresses in Birmingham.

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COMPANY PRODUCTION CRUDE OIL

	Feb. 1953 *tons*
Iraq Petroleum Co. Ltd. (Kirkuk)	1,595,187
Basrah Petroleum Co. Ltd. (Zubair)	228,278
Mosul Petroleum Co. Ltd. (Ain Zalah)	95,721
Petroleum Development (Qatar) Ltd.	300,378
Kuwait Oil Co. Ltd.	3,031,541
	Mar 1953 *Brls.*
Trinidad Petroleum Development Co. Ltd.	292,274
Kern Oil Co. Ltd.:	
California	110,907
Trinidad	86,758

UNIVERSITY OF SOUTHAMPTON

Esso Research Studentship

Applications are invited from men with a good University degree, with Chemistry as principal subject, for a research studentship in Chemistry, endowed by the Esso Petroleum Co. Ltd., at £260 p.a., to commence 1 October, 1953.

Candidates should apply to the Professor of Chemistry, from whom further particulars can be obtained, before 16 May.

UNIVERSITY COLLEGE, LONDON

Esso Studentship in Chemical Engineering

Applications are invited from men with a good University degree in Chemical or other branch of Engineering or in Chemistry for the Esso Studentship, founded by the Esso Petroleum Co. Ltd., tenable at the Ramsay Memorial Laboratory of Chemical Engineering at the above College from 5 October, 1953. The value of the studentship is £350 a year plus College fees.

Applications should be submitted to the Registrar, University College, Gower Street, London, W.C.1, by 15 May, 1953 giving full particulars of educational qualifications, industrial experience (if any), national service, and outside interests, together with the names of two referees.

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(An Anglo-Iranian photo)

OIL SEARCH IN TANGANYIKA. A seismic party working for D'Arcy-Shell Exploration project drilling a shot hole on Mafia Island, Tanganyika, East Africa.

VISCOSITY MEASUREMENT

Recently the U.S. National Bureau of Standards[1] completed an investigation on the determination of the viscosity of water, obtaining a value of 1.002 centipoise (1.0038 centistokes) at 20.00°C in place of 1.005 centipoise (1.0068 centistokes), which latter value is now used for the basis of viscometer calibration in the standard method IP 71/52 T, for determining kinematic viscosity. The NBS had planned to adopt the new value, beginning 1 July 1952, but in order to give industry an opportunity of studying and preparing for the effects of such a change, the NBS agreed to postpone the day of adoption to 1 July 1953. The Institute of Petroleum has therefore decided that, on and after 1 July 1953, the kinematic viscosity at 20°C of the primary calibrating liquid, namely triple-distilled water, in method IP 71, Viscosity (Kinematic) in c.g.s. Units, shall be taken as 1.0038 centistokes. The BSI and the ASTM have also agreed to adopt the new value from the same date. On and after 1 July 1953 it will be necessary to recalibrate all viscometers in accord with the new viscosity value for water or until this is done to multiply the present values obtained by the existing calibrations, by the factor 0.997.

Redwood viscosities, like Saybolt viscosities, are independent of the value accepted for the viscosity of water at 20°C. The formulae, however, for the interconversion of Redwood and kinematic viscosities will require modification. As regards the table[2] for conversion of kinematic viscosity to Redwood No. 1 viscosity, any amendments by employing the factor 0.997 probably come within the experimental error.

As Saybolt viscosities are independent of the value accepted for the viscosity of water at 20°C, so also is the viscosity index of an oil which is dependent only on its Saybolt viscosities at 100°F and 210°F. The formula, however, for converting kinematic viscosities to Saybolt viscosities will alter, and this alteration will necessitate a corresponding modification to existing tables for calculating viscosity index.

The use of the existing Table 1 of IP 73, Viscosity Index, instead of the table modified in accord with the new agreed viscosity value of water as calibrating liquid, would cause an error, which, operating in the direction of lowering the viscosity index, would have a maximum value of 1 V.I. unit.

Further information will be given in the *Journal* of the Institute.

1. *J. Res. Nat. Bur. Stand.*, 1952, **48**, 1-31.
2. "Standard Methods for Testing Petroleum and Its Products." Institute of Petroleum, 12th edn., 1952, p. 676.

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EAEG MEETING

The European Association of Exploration Geophysicists is holding its fourth meeting at the Maison des Centraux, 8 Rue Jean Goujon, Paris 8, on 20-22 May, when it is expected that at least 20 papers on geophysical prospecting will be presented.

Details are available from Dr. D. T. Germain-Jones, Kirklington Hall, nr Newark, Notts.

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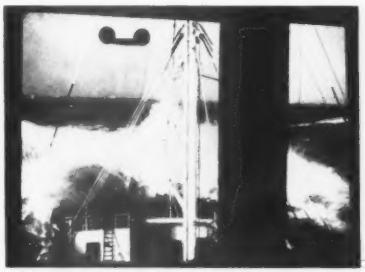

(An Anglo-Iranian photo)

ROUGH SEAS AHEAD. The 8400-ton tanker "British Lady" (British Tanker Co. Ltd.) forges through a 50-m.p.h. gale in the Atlantic.

FUELS FOR SPACE HEATING

Statistics covering fuels consumed in the U.S.A. for all residential purposes and for space heating of commercial buildings for the years 1935 to 1951 are available in U.S.B.M. Information Circular 7657. It is shown that liquid fuel rose from 9.6 per cent of total in 1935 to 28.2 per cent in 1951, extracted details being given in Table I.

Details of annual consumption of various liquid and gaseous fuels are given and extracts are set out in Table II.

Conversion factors used were:

	B.Th.U.
Heating oil:	
Distillate grades 1-4	5,824,980/brl
Residual grades 5-6	6,322,260/brl
Range oil	5,961,000/brl
Fuel oil for gas and electric mfg (15% distillate, 85% residual)	6,247,660/brl
Petroleum, crude and products	5,800,000/brl
Natural gas: Wet	1075/cu.ft.
Dry	1050/cu.ft.
Petroleum coke	30,120,000/net tons
Liquefied petroleum gas	95,500/U.S. gal

TABLE I

	1935	1940	1945	1950	1951
	Percentage of total				
Liquid fuel	9·6	18·2	16·1	26·2	28·2
Gaseous fuel	9·4	11·4	13·5	22·7	25·5
Solid fuel	80·1	69·1	68·8	48·2	43·0
Electricity	0·9	1·3	1·6	2·9	3·3

TABLE II

LIQUID FUELS

	Distillate grades 1-4	*Range oil, No. 1 fuel oil, and kerosine*	*Residual grades 5 and 6*	*Total*
	Thousands of barrels			
1935	53,797	21,526	23,056	98,379
1940	115,533	44,692	44,846	205,071
1945	121,342	51,021	43,874	216,237
1950	220,947	94,662	72,716	388,325
1951	249,258	102,847	76,164	428,269

GASEOUS FUELS

	Natural Gas		*Mfg and Mixed Gas*			
	Residential	*Commercial*	*Residential*	*Commercial*	*LPG*	*Total*
	Millions of therms					
1935	2,773·3	903·5	1,671·2	307·6	20·4	5,676·0
1940	4,064·3	1,226·2	1,758·8	371·5	128·0	7,548·8
1945	5,600·9	2,016·6	2,148·4	471·9	509·3	10,747·1
1950	11,561·6	3,496·6	2,277·5	607·2	1,931·5	19,874·4
1951	14,008·7	3,985·9	2,195·8	573·5	2,069·3	22,833·2

It is stated that at the beginning of 1952 there were 5,704,556 domestic oil burners in use in the U.S.A., compared with 914,280 at the beginning of 1934.

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MIDDLE EAST CRUDE PRICES

With effect from 1 April 1953 the Anglo-Iranian Oil Co. Ltd. has posted an export price for Kuwait crude f.o.b. Mina-al-Ahmadi. The price is $1.50 per barrel for gravity 31-31.9° API. For minor day to day variations in gravity, the conventional adjustment of 2 cents per barrel per degree is being retained.

The Company has also posted export prices for Iraq crude oils as: Persian Gulf—f.o.b. Fao, $1.75 per barrel for 36-36.9° API; Eastern Mediterranean—f.o.b. Tripoli or Banias, $2.29 per barrel for 36-36.9° API.

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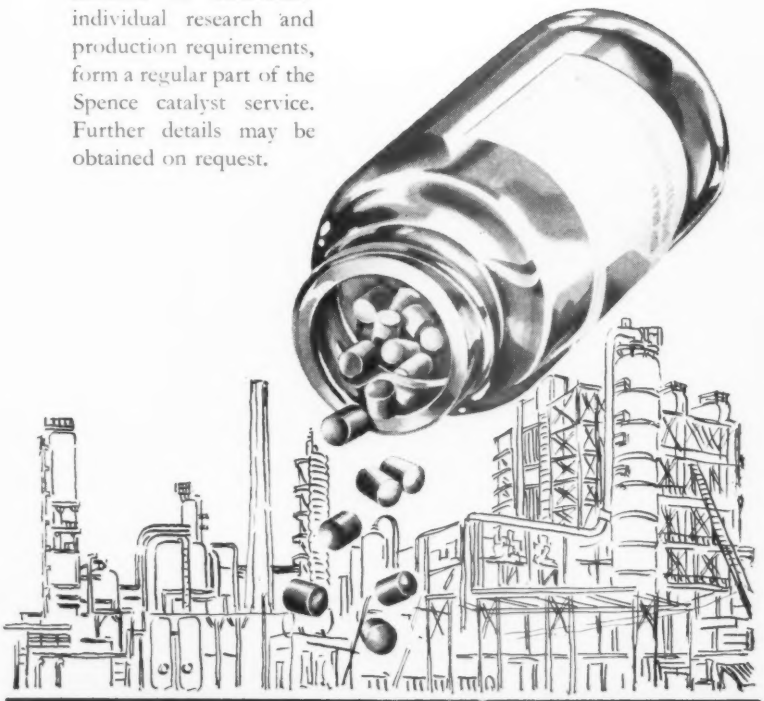

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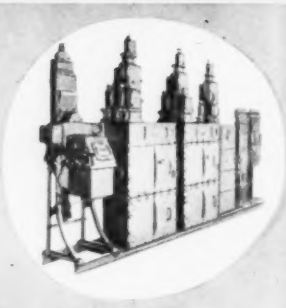

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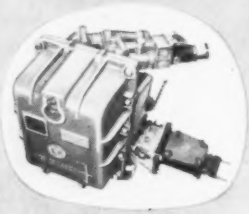

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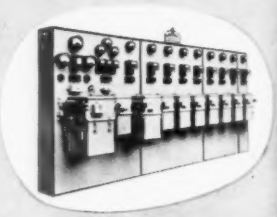

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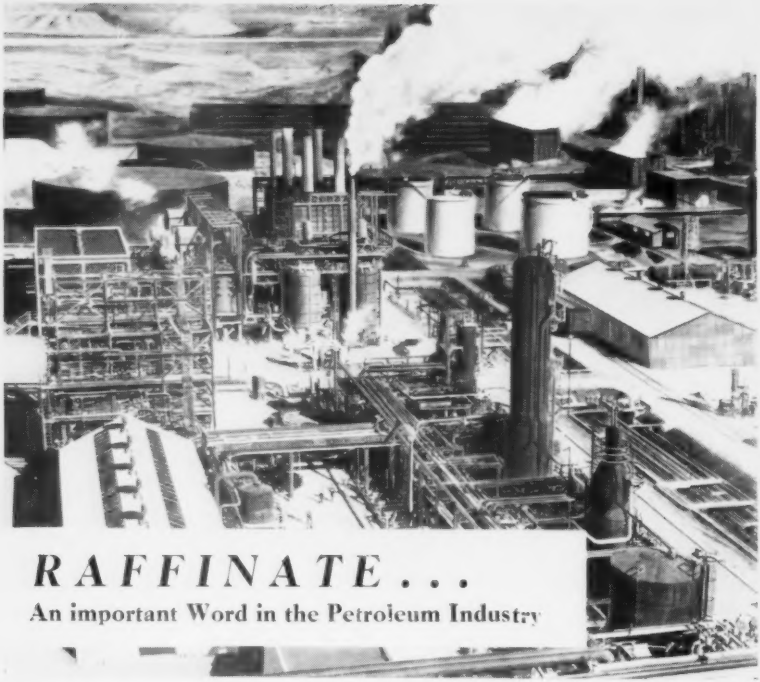

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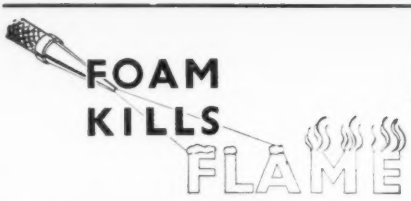

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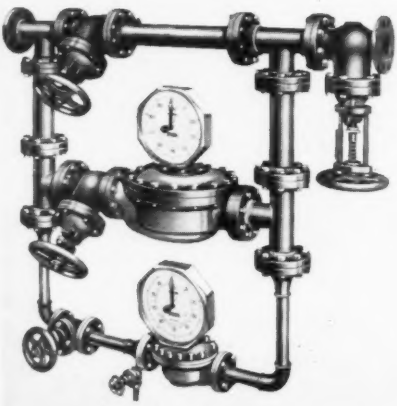

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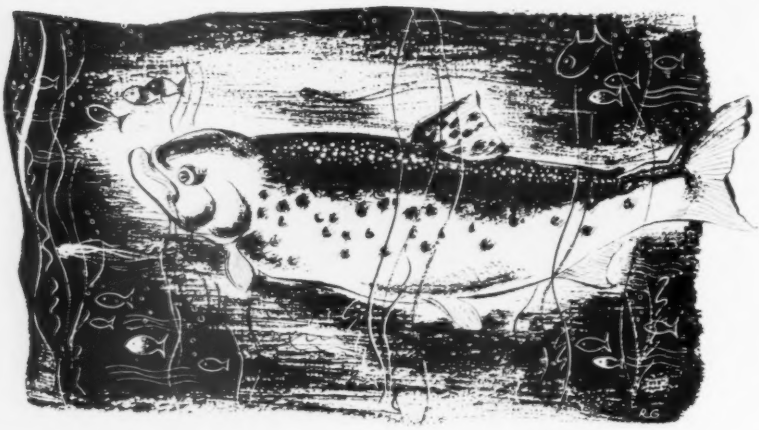

Old Cannibal

In his splendid silver youth he quivered on the fin in the quick-flowing shallows, or broke the surface after flies. Now in his black old age he lies in the deep hole under the bridge, killing the young fry, spoiling the fishing, hated by the angler. Catching him is a tricky problem, needing special skill and special equipment.

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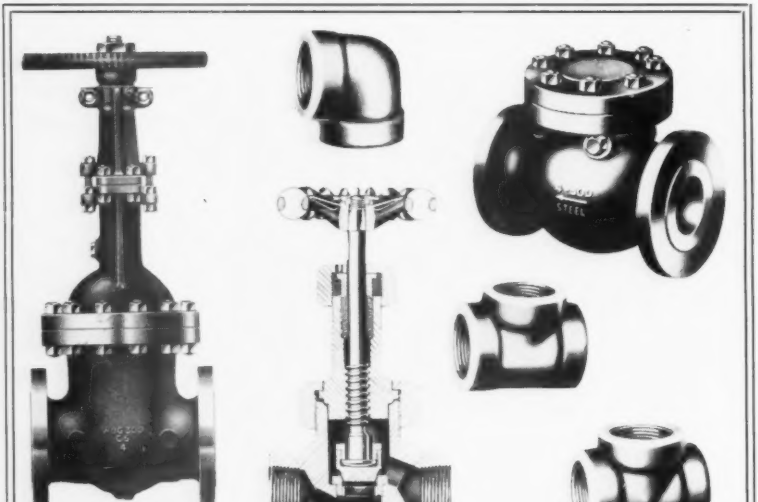

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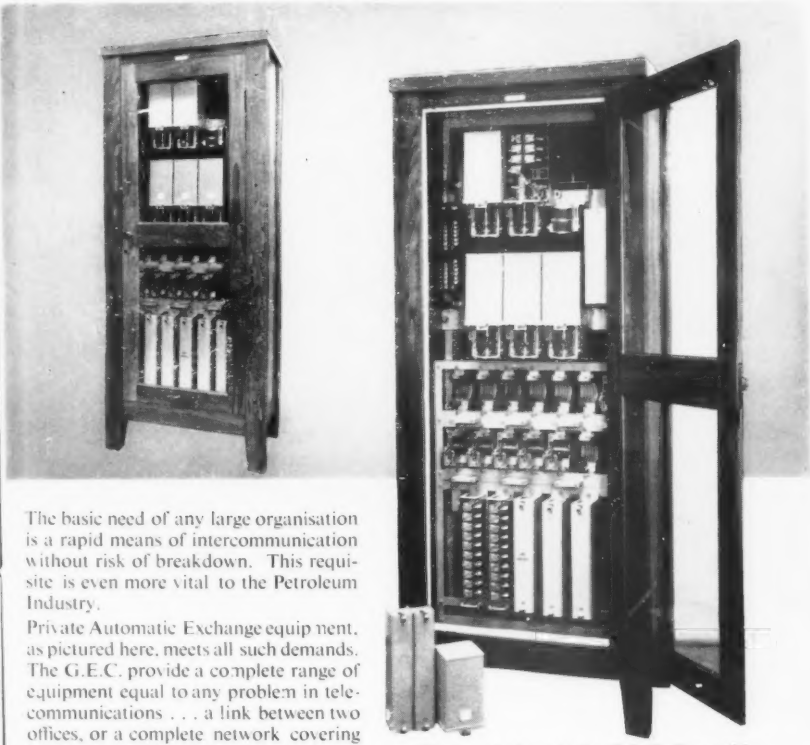

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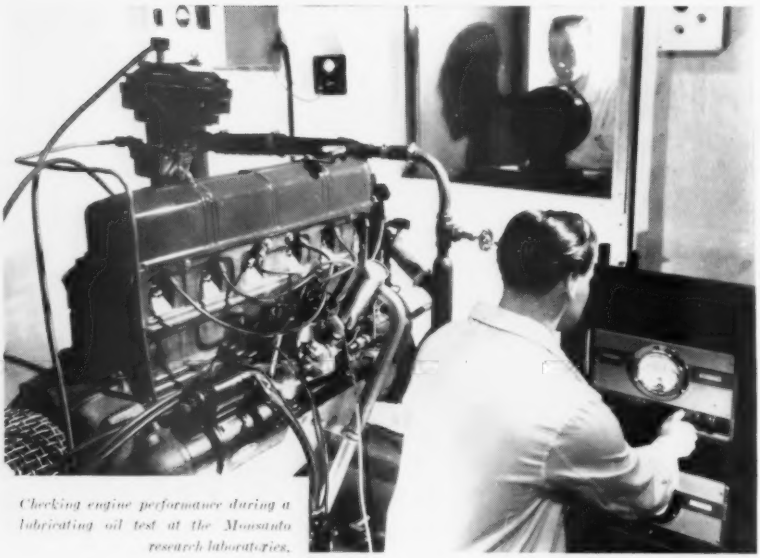

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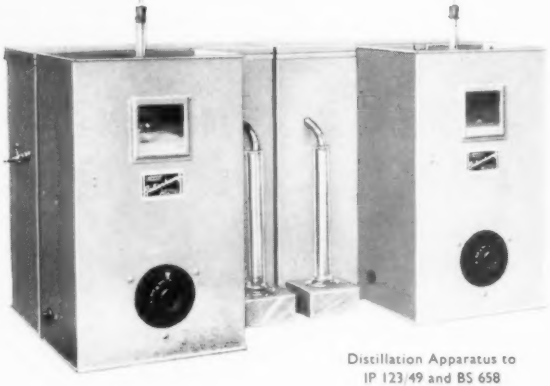

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